Effects of Floor Levels and Ventilation Rate on Indoor Radon and its Progeny inside Iraqi Kurdistan Hospitals

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Abstract

Effects of floor levels (ground, first and second) and ventilation rate on the density of indoor radon and its progeny have been evaluated inside most of public hospitals. Ventilation rate is represented by the air moving rate; poor, fair, good, very good. Locations of the selected hospitals had different geological formation in three main governorates: Erbil, Duhok and Sulaymaniya. Nuclear track detector type CR-39 (CR-39NTDs) has been used to measure track density of alpha particles that emitted from radon and its progeny. During spring season, 72 pair of exposure chambers (open-close chamber) equipped with 144 pieces of CR-39NTDs installed inside 24 rooms for three floors were employed. After 90 day of exposure, exposed detectors were etched in 6N NaOH at 70°C for 10 h. The highest and lowest radon concentration were in the hospitals of Shaheed Aso (Sulaymaniya city : 71.09±4.32 Bq.m^{-3})(fair ventilation) and Erbil Teaching (Erbil city : 48.02±3.77Bq.m^{-3}) (good ventilation). This was depended on the geological formation, type of building material, and the floor level. Therefore, the results showed that the average radon concentration and annual effective dose decreased gradually as the floor level increased. The highest and lowest of annual effective dose were found in ground and second floor, respectively. Thus, according to the annual exposure dose data, the workers were safety in most of the hospitals. More details about the type of building materials of the hospitals have been listed in full paper

Keywords

CR-39NTDs; Indoor Radon; Lung Cancer

Introduction

Exposure to radon in home is responsible for an estimated 20,000 lung cancer deaths each year. Radon is a health hazard with a simple solution. It is a naturally occurring radioactive gas that originates from the decay of uranium. Due to its relatively longer half life of 3.82 days, the most concerned radon isotope is ^{222}Rn (Durrani S A. Radon, 1993) which decays and produce a series of short lived particulate daughter products (^{218}Po, ^{214}Po, and ^{210}Po). After inhalation, it may cause significant damage to the delicate inner cells of the bronchioles which may lead to the occurrence of lung cancer (EPA. Consumer's, 2010). Deposition of the radon's daughter on the lung and trachea makes a risk of the carcinoma. Because radon's progeny produced by the emission of a heavy particles (alpha particles) , which makes a mutating of the DNA. And this refers to increase of the free radicals of the lung and trachea tissue (Ismail and Jaafar. Interaction, 2011).

Natural sources inherent to life on earth are considered to be major source of human exposure to ionizing radiation. Radon gas, gamma rays, cosmic (natural sources) radiations, and internal radiations constitute 2.4 mSv/y of the absorbed radiation dose. In addition, artificial and other sources contribute to 2.8 mSv/y(ICRP.Non-stochastic,1984 & Shankarnarayanan K. Ionizing, 1998) of the absorbed radiation dose. People may be exposed to external and internal radiations by inhalation and ingestion due to background radiations that exist in the environment. Radon exposure occupies 50% of the average annual dose contribution of population radiation exposure; thus, most of the risks are from the inhalation of radon gas (Somlai J. Radiation ,2009).

The most significant characteristic of the radon-222 gas is the four short-lived progeny products from polonium-218 (^{218}Po) to polonium-214 (^{214}Po), which, shortly after their formation get attached themselves to aerosol particles. However, a small fraction of these particles remains in an unattached form, depending on the movement of the air mass, which in turn depends on the installed ventilation systems (Ismail A H. Indoor, 2010).

According to the last research of the risks of radon conducted by Ismail & Jaafar (Ismail A H. Relationship, 2010), radon can be making of an infertility to men. Therefore, in the present study, beside of measure indoor radon concentration, the most important related to the estimation of a risks of inhalation of radon gas by the workers inside the hospitals has been measured. Potential alpha energy concentration, equilibrium factor between radon and its daughter, as well as the annual effective dose were considered important parametersin order to find variation in radon concentration for three floors ground, first, and second.

Material and Methods

Iraqi Kurdistan region consists of three main governorates; Erbil, Duhok and Sulaymaniya which are different from each other on geographical location shown in Fig. 1. Passive radon dosimeter geometry, a closed-opened chamber into which radon diffuses, has been calibrated by Ismail and Jaafar (Ismail A H. Design, 2011).

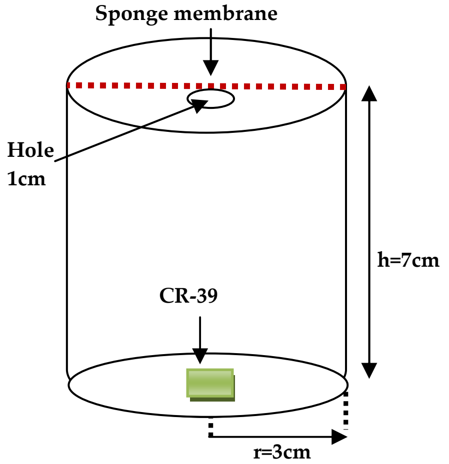

FIG.1 SCHEMATIC DIAGRAM OF THE OPTIMUM RADON.

The schematic diagram of the chamber is shown in Fig. 2. The technique used in this survey is based on CR-39NTDs (Moulding, UK, manufactures the detectors), with area of 1.5×1.5 cm^2 which is fixed by double-stick tape at the bottom of the dosimeter.

In the cover, there is a hole covered with a 5-mm thick soft sponge. The design of the chamber ensures that the aerosol particles and radon decay products are deposited on the sponge from outside and only radon, among other gases, diffusing through it to the sensitive volume of the chamber. The dosimeters have been distributed inside 8 government hospitals in three main regions (Erbil, Duhok and Sulaymaniya) in Iraqi Kurdistan region (Fig.2), in each of which they were distributed on three floors (ground, first and second). Nuclear track detector type CR-39 (CR-39NTDs) was used to measure track density of alpha particles that emitted from radon and its progeny. During spring season, 72 pair of exposure chambers (opened-closed chamber) were equipped with 144 pieces of CR-39NTDs installed inside 24 rooms for three floors ; 3 rooms in each floor, on the top about 2 m above the floor.

FIG.2 SKETCH MAP OF THE AREA UNDER STDUY (KURDISTAN REGION)

After 90 day of exposure, exposed detectors were etched in 6N NaOH at 70°C for 10 h. The counting of alpha damage tracks was done using an optical microscope with a magnification of 400X used.

Measurements of Potential Alpha Energy Concentration (PAEC) were necessary to estimate effective dose from ^{222}Rn progeny and its concentration in the present locations. PAEC be measure in terms of working level (WL) unit (Khan A J.Calibration,1990).

$$WL = F\, C_{Rn} / 3700 \qquad (1)$$

Where F is the equilibrium factors, which can be obtained from the following relation (Ab-Murad K. Natural ,2005).

$$F = a \exp (bD_o / D) \qquad (2)$$

D and D_o represents the track densities (track/cm^2. day) of the open (D: without filter) and closed (D_o: with a filter) – can technique respectively. The values of two constant a= 14.958 and b= -7.436 and C_{Rn} is the ^{222}Rn concentrations (Bq/m^3) which can be obtained by relation

$$C_{Rn} = D_o / K \qquad (3)$$

Where, K is the detector sensitivity (K = 0.23 track.cm^{-2} per Bq.m^3) obtained from the calibration experiment in

the works of Ismail and Jaafar (Ismail A H. Design, 2011).

The effective dose (H in units' mSv/y) of radon and its progeny, can be calculate from the following relation (UNSCEAR. Sources, (2000).

$$H= C \times F \times O\times T \times D \quad (4)$$

Where C is the radon concentration in $Bq.m^{-3}$, F equilibrium factor, O for occupancy factor (0.8) (UNSCEAR. Sources, (2000).,T for time (8760 $h.y^{-1}$) and D for dose conversion factor (9×10^{-6} $mSv.h^{-1} (Bq.m^{-3})^{-1}$).

TABLE 1 RADON CONCENTRATION, EQUILIBRIUM FACTOR, PAEC AND ANNUAL EFFECTIVE DOSE INSIDE HOSPITALS OF IRAQI KURDISTAN REGION.

Regions	Hospital	Equilibrium Factor (F)	PAEC (mwL)	Annual effective dose (mSv/y)	Radon Concentration ($Bq.m^{-3}$)
Erbil	Rizgary	0.307±0.079	4.41±0.93	1.19±0.13	54.04±6.08
	Emergency west	0.311±0.077	4.34±0.83	1.16±0.07	52.3±4.39
	Erbil Teaching	0.360±0.01	4.66±0.36	1.1±0.08	48.02±3.77
	Paediatric	0.364±0.001	5.93±0.61	1.38±0.14	60.38±6.34
Duhok	Azadi Teaching	0.37±0.003	6.53±0.52	1.52±0.13	65.36±5.07
	Emergency Teaching	0.362±0.009	5.77±0.55	1.34±0.12	59.05±4.49
Sulaymaniya	Shahid Aso	0.368±0.005	7.06±0.32	1.64±0.07	71.09±4.32
	Shorsh General	0.364±0.002	6.65±0.42	1.54±0.09	67.56±4.05

TABLE 2 GEOLOGICAL FORMATION OF IRAQI KURDISTAN REGION AS RELALITED STUDY

Governorate	Hospitals	Geological formation
Erbil	Rizgary Emergency west Erbil Teaching Maternity and teaching	Region consists of the plains and hills . It consists of sandstone, limestone and shale
Duhok	Azadi Teaching Emergency Teaching	Region consists of the plains, sediment logical and mountains. It consists of marly limestone, calcarenite shale, sandly limestone and conglomerate
Sulaymaniya	Shahid Dr. Aso Shorsh General	Region consists of the Rocky Mountains and valleys. It consists of rocks, limestone, conglomerate, biogenic limestone, pebbly, calcarenite and sandstone

TABLE 3 INDOOR RADON CONCENTRATION AND ANNUAL EFFECTIVE DOSE FOR DIFFERENT FLOORS IN INSIDE HOSPITALS IN IRAQI KURDISTAN REGION.

		Radon Concentration ($Bq.m^{-3}$)			Annual effective dose (mSv/y)		
Hospitals	Levels	Min	Max	Average	Min	Max	Average
Rizgary (Erbil)	Ground	56.99±0.22	61.58±0.62	59.34±2.23	1.28±0.016	1.32±0.032	1.3±0.098
	First	53.29±0.14	57.39±0.34	55.39±2.05	1.12±0.022	1.26±0.024	1.24±0.068
	Second	44.55±0.44	49.65±0.82	47.4±2.61	1.01±0.028	1.08±0.018	1.04±0.086
Azadi Teaching (Duhok)	Ground	67.16±0.34	73.64±0.44	70.22±2.98	1.56±0.022	1.68±0.032	1.65±0.092
	First	63.89±0.52	68.16±0.62	65.79±2.64	1.46±0.042	1.54±0.012	1.51±0.064
	Second	57.72±0.58	62.28±0.84	60.09±2.24	1.36±0.042	1.44±0.028	14±0.078
Shahid Aso (Sulaymany)	Ground	72.34±0.45	79.01±0.64	75.53±2.86	1.66±0.023	1.74±0.42	1.72±0.092
	First	68.33±0.26	73.72±0.48	70.82±2.64	1.59±0.042	1.65±0.032	1.64±0.068
	Second	64.44±0.12	69.76±0.56	66.94±2.28	1.54±0.012	1.58±0.018	1.57±0.082

Results and Discussion

The first part of this study involved measurement of indoor radon concentration (C_{Rn}), (PAEC), equilibrium factor (F) and annual effective dose (H) inside 8 government hospitals in Iraqi Kurdistan. Table 1 shows that the equilibrium factor (F) for each hospital is different than that for other hospitals, because the ventilation rates are different. Similarly, average of indoor radon concentration and annual effective dose for the hospitals of each governorate are different compared to that of other governorates. This is because the geological formation of Erbil governorate different from the geological formation of Duhok and Sulaymaniya. More details about geological formation are listed in Table 2 (Kamal H. K , 2004) .

Fig. 3 shows the distribution of radon concentration inside 8 government hospitals in Iraqi Kurdistan region, in which the highest indoor radon concentration was found in Shahid Aso hospital in Sulaymaniya city (71.09±4.32 Bq.m^{-3}), and the lowest indoor radon concentration was found in Erbil Teaching hospitals in Erbil city (48.02±3.77 Bq.m^{-3}), because these areas are different from each other by their geographical location and geological formation.

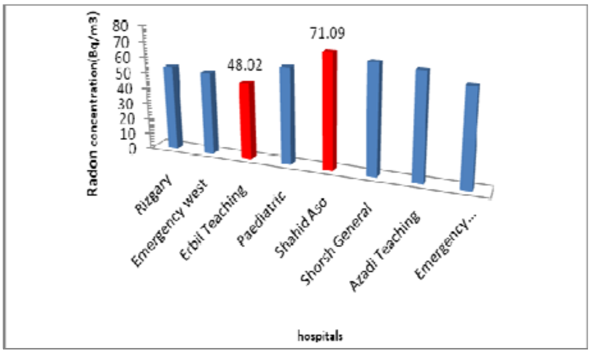

FIG. 3 DISTRIBUTION OF RADON CONCENTRATION INSIDE GOVERNMENT HOSPITALS IN IRAQI KURDISTAN

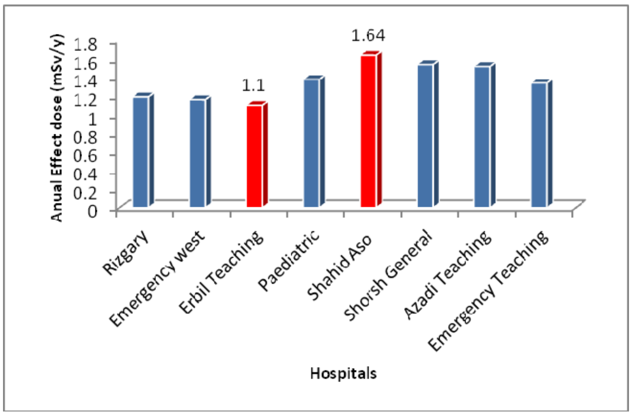

FIG. 4 DISTRIBUTION OF ANNUAL EFFECTIVE DOSE INSIDE HOPITALS OF IRAQI KURDISTAN

On the other hand, Fig. 4 shows a combination relation of annual effective dose and indoor radon concentration inside eight government hospitals.

The second part of this study was to find an impact floor level of the hospitals on the concentration of indoor radon for each floor. Indoor radon concentration and annual effective dose for the floors of ground, first and second have been estimated, and the data are listed in Table 3. The highest indoor radon concentration and annual effective dose were found in ground floor as well as lower indoor radon concentration and annual effective dose in second floor, as shown in Fig. 5.

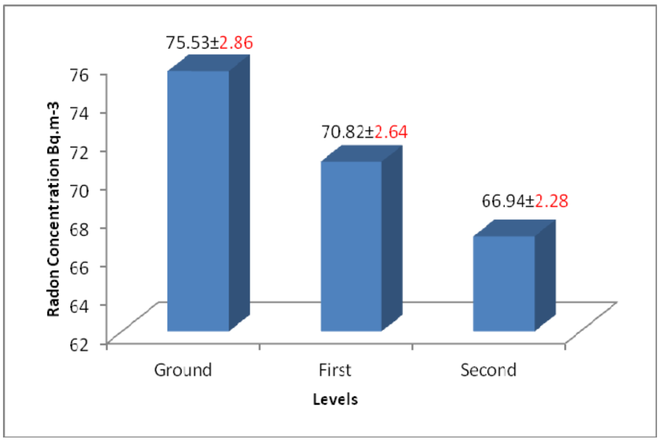

FIG. 5 VARIATION OF RADON CONCENTRATION WITH FLOOR LEVELS IN SHAHID Dr. ASO HOSPITAL

It is clear that the average indoor radon concentration decreases as the floor level increases and this variation may be attributed to how close or how far the floor is from ground since soil represents the main source of indoor radon in addition to many other reasons such as the fact that upper floors are better ventilated than lower floors exposed to dust and other forms of contaminations

Conclusion

Floor levels and geological formation of the Iraqi Kurdistan hospitals had affect on the concentrations of indoor radon and its progeny Locations of the selected hospitals had different geological formation in three main governorates: Erbil, Duhok and Sulaymaniya. Nuclear track detector type CR-39 has been used to measure track density of alpha particles that emitted from radon and its progeny during spring season. The present study consisted of two main parts; the first was the effect of the geological formation on indoor radon concentration, which has been investigated. The highest and lowest radon concentration were in the hospitals of Shaheed Aso (Sulaymaniya city: mountain

region) and Erbil Teaching (Erbil city). The second part was related to the effects of floor level on the concentration of indoor radon. Therefore, the results showed that the average radon concentration and annual effective dose decreased gradually as the floor level increased. The highest and lowest of annual effective dose were found in ground and second floor, respectively.

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